SEARCHING BEHAVIOR OF *HIPPODAMIA CONVERGENS* LARVAE (COCCINELLIDAE: COLEOPTERA)*

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Introduction

Survival and development of predaceous Coccinellidae depend in large part on their ability to find food (Hodek, 1973). Coccinellid larvae exhibit different searching patterns before and after finding prey; the path of a larva just after consuming a prey item is generally more tortuous than before the encounter (Banks, 1954; Banks, 1957; Kaddow 1959). When the prey are gregarious, this type of altered searching behavior is thought to increase the chance of finding additional prey (Banks, 1957). In the present study I describe the searching behavior of larvae of the convergent lady beetle, *Hippodamia convergens* (Guerin), before and after feeding on the spotted alfalfa aphid, *Therioaphis maculata* (Buckton).

Materials and Methods

Adult *H. convergens* were collected from a field of alfalfa located at the Arizona State University Experimental Farm, Tempe, AZ. Copulating pairs were isolated for 48 hrs, then the females were removed and placed in six-dram plastic vials lined with paper toweling. The toweling was moistened periodically. Isolated females were supplied daily with thirty fourth-instar or adult *T. maculata* (Nielson and Currie, 1960) collected from the alfalfa field by sweep netting. The vials were incubated at 32° C for 4 or 5 days during which time the fertilized females deposited clusters of eggs on the toweling; then the female beetles were removed and the brood chambers incubated for another two days. After hatching, the first instar larvae remain clustered around the egg shell, but because of cannibalism it was necessary to immediately separate the newly hatched larvae. Individual larvae were transferred to new vials, by

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the use of a fine camel-hair brush, together with five immature aphids. After moulting to the second instar and thereafter the larvae were provided thirty aphids per day. Following the third molt the new fourth instar larvae were used for experimentation.

To study searching behavior before and after feeding, an artificial searching arena was constructed similar in design to the arenas of Fleschner (1950) and Banks (1957). A twelve inch square plywood board was covered with buff-colored art paper and surrounded by an electrically heated wire. The arena was uniformly illuminated by a fluorescent light suspended two feet above the center, and all tests were performed at room temperature. Tracks of the larvae were recorded by tracing lightly with a pencil, and 30 sec intervals were noted on the tracks. Track diagrams were enlarged with an overhead projector. The number of degrees of each turn, whether to the right or left, was measured with a protractor. The data were expressed as the total number of degrees turned, which was a function of the number and type of turns the larvae made. Statistical analysis was done with Student's t-test.

Results

Sixteen fourth instar *H. convergens* larvae were starved for 4 hrs prior to testing. Each larva was placed in the center of the arena under a vial, and timing commenced when the vial was removed. The larva was followed by a pencil tracing and 30 sec intervals were recorded on the track for a total test period of 5 min. At this time an adult *T. maculata* was placed directly in front of the larva; the aphid was seized and rapidly consumed. The track was again traced when the larva began to move after feeding, and 30 sec intervals were recorded for 5 min. This test procedure was repeated for each of sixteen larvae.

The movements of larvae before feeding were less tortuous and a much larger portion of the arena was searched; after feeding the larvae concentrated their search in the vicinity where the aphid was discovered. The track consisted of numerous turns and frequently areas previously searched were revisited several times. Analysis of the tracks confirmed these observations (Fig. 1). For three minutes following the consumption of an aphid the larvae made more turns than they did prior to feeding, but in the final two minutes of observation the fed larvae appeared to revert to their pre-fed

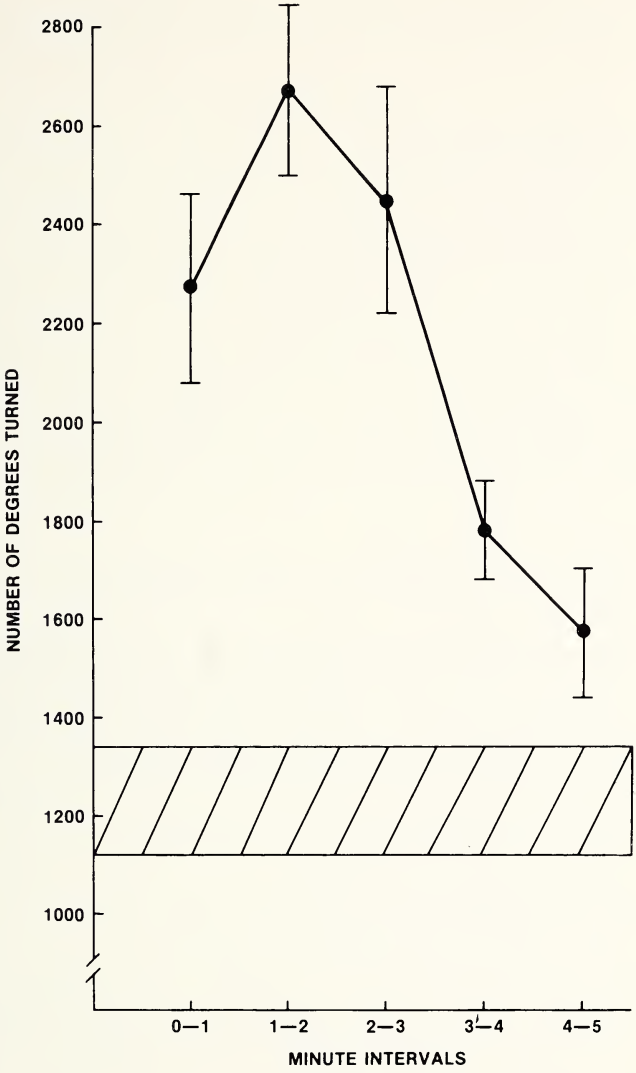

Figure 1. Searching movements of fourth instar *H. convergens* larvae during a five minute interval before and after consuming one adult *T. maculata*. The bar represents the cumulative mean ± one standard deviation of the numbers of degrees turned by larvae for five 1-minute-intervals prior to feeding.

searching pattern. The total number of degrees turned was 6200.3 ± 992.0 before feeding and 12058.8 ± 1798.8 after feeding ($p < 0.001$).

Discussion

The searching movements of fourth instar *H. convergens* larvae before finding prey generally consist of wide sweeping turns. After consuming one adult *T. maculata* the searching movements are modified; initially movements consist of many small turns in the immediate vicinity of the previously consumed prey. With time the movements become more characteristic of the pre-fed state. Banks (1957) noted a similar searching behavior in a study of *Adalia bipunctata* (L.) and the aphid *Myzus persicae* (Sulz.), and Kaddow (1959) found the same searching movements in larvae of *Hippodamia quinquesignata* (Kirby) fed pea aphids, *Macrosiphum pisi* (Kaltenbach). Modification of turning movements after finding the first host is common to other entomophagous and parasitic insects (Fleschner, 1950; Laing, 1937).

It appears that coccinellid larvae lack sophisticated sensory apparatus and do not discover their prey until actual contact occurs (Hodek, 1973). Furthermore, this undirected searching is very inefficient in that much time and energy are wasted revisiting areas previously searched (Banks, 1957). If one assumes that the searching behavior of coccinellid larvae is indeed undirected, then the number of encounters between predator and prey would be merely a function of their respective population densities. However, this assumes that the chance of finding a second prey is the same as that for the first. On the other hand, if after the first prey encounter the predator alters its pattern of search in such a way as to increase the likelihood of capturing additional prey, then the predator has become more efficient even though its searching is still undirected (in terms of sensory capability). *T. maculata* are colonial and not uniformly dispersed throughout their habitat. With this characteristic in mind it would seem advantageous for *H. convergens* larvae, having encountered a single *T. maculata,* to modify their searching behavior in order to exploit the gregarious nature of their prey. Since survival and reproduction of predators like *H. convergens* is dependent upon finding adequate food (Hodek, 1973), a strong selection pressure probably exists for behaviors which improve food finding capabilities. Therefore, it is suggested that the change of

searching pattern by *H. convergens* larvae after finding one prey item is adaptive.

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References

Banks, C. J.
1954. The searching behavior of Coccinellid larvae. Br. J. Anim. Behav. **2:** 37–38.
1957. The behavior of individual Coccinellid larvae on plants. Br. J. Anim. Behav. **5:** 12–24.

Dixon, A. F. G.
1959. An experimental study of the searching behavior of the predatory Coccinellid beetle *Adalia decempunctata* (L.) J. Anim. Ecol. **28:** 259–281.

Fleschner, C. A.
1950. Studies on the searching capacity of the larvae of three predators of the citrus red mite. Hilgardia. **20:** 233–265.

Hodek, I.
1973. Biology of Coccinellidae. Academia Publishing House of the Czechoslovak Academy of Sciences, Prague, 1973, 260 pp.

Kaddow, I.
1959. The feeding behavior of *Hippodamia quinquesignata* (Kirby) larvae. Univ. Calif. Pubs. Entomol. **16:** 181–228.

Laing, J.
1937. Host finding by insect parasites. I. Observations on the finding of hosts by *Alysia manducator, Mormoniella vitripennis,* and *Trichogramma evanescens.* J. Anim. Ecol. **6:** 298–317.

Nielson, M. W., and W. E. Currie
1960. Biology of the convergent lady bird beetle when fed a spotted alfalfa aphid diet. J. Econ. Entomol. **53:** 257–259.